4. The ultimate survival of those who acquire a relative immunity will tend to diminish the severity of the disease, but many generations may be required to accomplish this.

5. The opportunities for infection, now universal in cities, will diminish gradually in civilized lands by lessening the danger from advanced cases, also from bovine sources. For many years, however, the number of "carriers" will increase owing to improved care, longer life, and higher standards of living among the people.

6. The best degree of resistance against tuberculosis that has been attained by experiments on the lower animals involves inoculation of living bacilli. This is of little value because of short duration of the protection and the danger of sequestered bacilli.

7. The natural infection of human beings takes place largely in childhood and increases the resistance to subsequent disease in a large measure. Under improved care of the tuberculous and better hygiene the amount and frequency of severe infections should diminish, while the number of those with slight, relatively harmless infections should relatively increase.

8. Adults withstand exogenous reinfection under extreme exposure, partly on account of slight infections in earlier life and favorable occupations, environment, and nutrition.

9. The specific immunity acquired from natural infection is largely due to cellular reactions of bacteriolytic nature, which take place outside the blood stream for the most part.

10. The interaction between the ferments of the body cells and those of the bacillus, lead to heightened activity of the lytic power, both lipolysis and proteolysis.

11. The tuberculin sensitiveness or "allergy" is the chief indication of specific resistance. In the patient most of the inflammatory symptoms are due to the actively working immunity functions.

12. In the therapy of tuberculosis this principle should be applied:

To avoid interference with Nature's powers of resistance when she is attempting to localize the infection with apparent success.

FEVER IN TUBERCULOSIS.[1]

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The contributions of physiology relating to heat production and heat dissipation, and the factors responsible for the maintenance of body temperature, are of special value for the correct interpretation of the pathology of fever. The special role of bacteria in the production of fever and the more recent work by Vaughn showing the part played by the toxic radicle of the protein molecule in the etiology of fever are also pertinent to the elucidation of this subject, and of paramount importance to the further development of a more comprehensive understanding of the basic factors in relation to fever. However, in the present paper, it is desired to emphasize only the clinical aspect of fever as observed in pulmonary tuberculosis.

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[1] Read before the Saranac Lake Medical Society, Saranac Lake, New York, Dec. 30, 1913.

Since temperature and fever are so closely related, it might be of interest to precede the discussion by a brief historical sketch of the thermometer. From earliest times the body temperature has occupied a place in the scale of heat measurements, and physicians have long recognized an increase in the blood temperature as a cardinal symptom of fever, although the degree of fever was measured by the pulse acceleration.

About 1610 Galileo constructed the first thermometer. This consisted of a glass bulb containing air, connected to a glass tube of small bore, dipping into a colored fluid. Owing to changes resulting from atmospheric pressure, this style of thermometer proved unsatisfactory. Some years later Galileo introduced a second type of thermometer, familiar to us at the present day, containing a liquid hermetically sealed in a glass bulb with a fine tube attached. In 1710 Isaac Newton proposed a scale, divided into twelve parts, in which zero represented the freezing-point of water and twelve the body temperature. Gabriel Daniel Fahrenheit, in 1714, in devising the scale now in general use, also employed the temperature of the human body as one of the major divisions of his scale. Traub, Baronsprung, and Wunderlich established the value of the clinical thermometer to medicine. From this period, about 1850, the clinical thermometer has become an important part of the physician's accoutrement.

METHODS OF TAKING TEMPERATURE. The first requisite in taking temperature is a standard thermometer. Out of a series of eighty-three certified thermometers tested in a water-bath, seventeen showed a variation of from 0.3° to 0.6°. Comparative rectal readings approximated closely the discrepancies obtained by the water-bath. To corroborate these tests, six thermometers showing marked error were forwarded to the Bureau of Standards at Washington, D. C. The letter here reproduced needs no comment: "The Bureau begs to state that the five clinical thermometers which exceeded the limits of allowable error were in error by from 0.4° to 0.6° at different points. The readings of the thermometer which retreated were not recorded. As these instruments were so badly in error the sign of the correction was not carefully noted."

A further series of fifty-five were examined by the Bureau; thirty-five passed and twenty were rejected. To obtain an accurate reading irrespective of type of thermometer, demands a period of from five to ten minutes. Many authorities, including Walther, Nordrach, Penbold, and King, advocate rectal temperatures on account of greater accuracy. However, parallel determinations by Schroeder, Bruhl, and others have shown that the discrepancies between oral and rectal readings are so slight that they can be ignored. Conditions regulate the choice at times. Thus the rectum or axilla is preferable in children, the weak or acutely ill, patients suffering from marked dyspnea, oral or throat inflammations, and nasal obstruction. When fever is suspected, but not revealed by oral reading, rectal reading is indicated as control.

The disadvantages of rectal readings are obvious. The manipulations are distasteful, and in ambulant cases, necessitates the patient retiring to his room. Care must be taken that the rectum is free from fecal matter. It has been shown that exercise has a decided influence on the rectal temperature, due presumably to the close approximation of the large muscles in this region. A preliminary rest is therefore especially indicated before rectal readings, as this method does not record the actual body temperature after exercise. The axilla still remains in high favor, especially in certain European centres. Cornet favors rectal temperatures and prefers axilla to mouth readings. Franck concludes that the axilla method of taking clinical temperature observations no longer meets the requirements of diagnosis on account of possible inaccuracies and the time required. He regards rectal measurements as the quickest and most accurate means. So good an authority as Turban is satisfied with oral temperatures, and he voices the consensus of opinion, at least in this country.

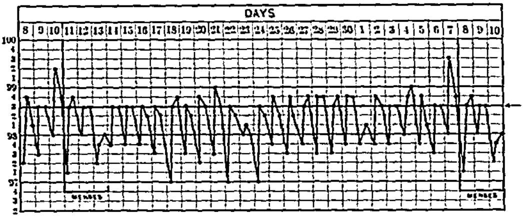


FIG. 1.—Case 2977. Female, aged nineteen years. Premenstrual fever in an afebrile case of incipient tuberculosis.

WHAT IS NORMAL TEMPERATURE? Since in no other disease are minor fluctuations of temperature of greater import, the establishment of the normal temperature range is the first essential in determining the significance of fever in tuberculosis. A detailed study of the literature shows obvious disparities among authors in their ideas regarding normal temperature. The following tabulation by different authors gives the *maximum normal:*

Wunderlich: Axilla, 98.94° F.; mouth, 99.3° F.

Vierordt: Mouth, 99.6° F.

Turban: Mouth, 98.9° F.

Stewart: Axilla, 99.5° F.; mouth 99.1° F.

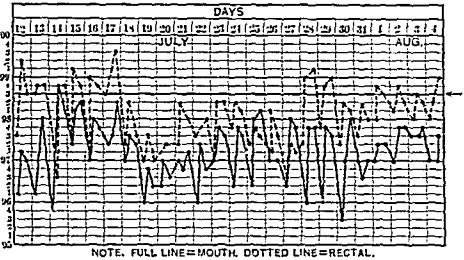
Foster: Axilla, 36° to 37.5° C.; mouth, 0.25° to 1.5° C. higher than axilla.

Finlayson: Mouth, 98.6° F.

Sahli: Mouth, 99.32° F.

Meyer states that oral readings exceeding 37.3° C. represent fever.

Schneider and Weise concur with this view.



NOTE. FULL LINE=MOUTH. DOTTED LINE=RECTAL.

Fig. 2.—Case 3042. Female, aged thirty-seven years; stage three; progressive type. Comparative oral and rectal readings showing subnormal temperature.

Turban considers 99.3° F., *if frequently recurring,* as fever. Sahli says 99.32° F. is within physiological limits. This, in consumption, would correspond to a rectal temperature of 100.4° F., and so indicate fever.

The above discrepancies can hardly be accounted for by errors in technique. Sex, time of day, and season are not mentioned, and the possible inclusion by the older authorities of cases of early tuberculosis might offer a partial explanation. Notwithstanding these facts it is reasonable to suppose that normal temperature has a considerable range, and is of some moment in estimating the *degree of temperature in tuberculosis.*

The diurnal range is approximately 1.8° F. Any definite increase beyond this limit is considered by some as indicating fever. Thus we may have the paradoxical condition of a patient with fever and apparently normal temperature. *The normal diurnal curve is* modified by exercise, food, seasonal change, the ingestion of hot or cold liquids, and psychical conditions, such as, anger, grief, and mental concentration. A physician of my acquaintance could, by matching himself against a worthy chess opponent, regularly raise his temperature over 100° F. Care must be taken to avoid misinterpretation of the slight premenstrual increase in temperature normally present in some cases. When slight fluctuations are present it has been suggested to take readings over a lengthy period, and by this means the normal range for any certain individual can be approximately obtained.

The Bacteriology of Fever. In the bacteriology of fever in tuberculosis we are confronted by a complex problem which has not yet been completely solved. The toxins of the tubercle bacillus

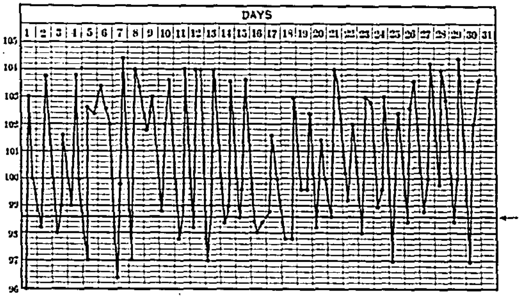


Fig. 3.—Case 2189. Female, aged twenty-six years; stage three. That the above hectic type of fever exhibiting such wide temperature variations is compatible with life for a period of months is clinically of decided interest, indicating that the prostrating action of the fever is more kindly borne in tuberculosis than in most other infections.

are capable in themselves of inducing fever. This is well exemplified in the tuberculin reaction, where the question of mixed infection is certainly excluded, and in the fever accompanying an exacerbation of a tuberculous process. For many years the exact role played by secondary organisms in the production of fever in tuberculosis has caused lively discussion; among such organisms may be mentioned the various streptococci, Staphylococcus pyogenes aureus, Friedländer's bacillus, influenza bacillus, and pneumococcus. They may be readily demonstrated in tuberculous sputum, and can be recovered at autopsy directly from the involved tissue. The question is one of indecision in individual cases, but we may, on clinical grounds, with some degree of certainty, assume that in certain cases, especially those in the terminal stages, and exhibiting a hectic type of fever, are suffering from a mixed infection.

CHARACTER OF FEVER IN TUBERCULOSIS. Patients exhibit marked differences in their reaction to fever and to the clinician; the striking contrast between the apparent comfort of the patient and the temperature record forms one of the most marked peculiarities of the fever in tuberculosis. On the other hand, some patients, especially those with a neurotic tendency, are notably affected. The apparent selective action of the toxin is evident in some cases and may lead to error in diagnosis. The pulmonary lesion may remain latent, or apparently so, and yet evidence of intoxication appears in many cases. Thus we may see cases where the gastro-intestinal symptoms dominate the clinical field, obscuring the real nature of the infection. At other times the condition may be masked by an accompanying neurasthenia. Disturbances of the circulatory system may lead to false conclusions, especially when anemia is present. A profound weakness may be the sole complaint for which the patient is unable to give an explanation. Finally, fever may be present in some cases with such slight constitutional symptoms that it escapes even the patient's notice.

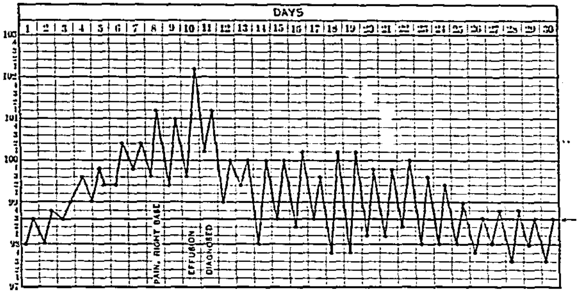


FIG. 4.—Case 2281. Male, aged seventeen years. After a gradual rise in temperature for a few days, onset of base pain; two days later effusion detected. The temperature reactions in cases complicated by pleural effusion are variable, but the above chart expresses, in a fairly typical manner, the reaction in those cases terminating favorably.

Unfortunately no typical temperature curve exists in tuberculosis as in some other infectious diseases. The fever occurring at the onset can so closely simulate the typical temperature curve observed in certain other diseases, notably pneumonia, typhoid, and malaria, that error not infrequently arises, the further course of the disease alone suggesting the true nature of the causal agent. A certain type of initial fever, however, is worthy of mention, because of its frequent association with beginning tubercle formation. It is distinguished by a slight post meridian temperature ranging from 99.2° F. to 100.2° F., evanescent, showing marked fluctuation and requiring two-hour readings for proper interpretation.

In a study of the temperature curve of pulmonary tuberculosis over a period of months the alternating febrile and afebrile states and the extreme irregularity of these intermittent periods, form one of the most striking characteristics. The curve also represents in some cases, fairly typically, the actual clinical course. In the progressive type the afebrile periods become shorter, the febrile correspondingly longer, with increase in the temperature range, and toward the end the fever generally assumes the hectic form, A reversal of the above picture in cases with a favorable outlook commonly occurs.

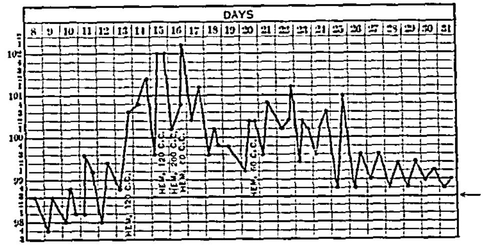


Fig. 5.—Case 2731. Male, aged twenty-one years. Hemoptysis with temperature. The frequent rise in temperature preceding hemoptysis is noted. Following the hemoptysis a considerable rise occured. On account of bacteriological difficulties the role of secondary organisms in the production of hemorrhages and their relation to the different types of fever has in our hands received no definite confirmation.

Williams, Minor, and others have drawn attention to the frequently accompanying subnormal temperature to which they attribute much importance. The temperature is extremely labile, oscillating readily to slight stimuli. Exercise can induce a decided rise in temperature, the reaction being more pronounced when little or no exercise has been previously allowed. Eating and mental excitement often lead to an increase in temperature.

The fever is arbitrarily divided into three parts, the divisions depending on the degree of temperature: First, from 99.2° F. to 100.2° F.; second, from 100.2° F. to 102.2° F.; third above 102.2° F. The fever may be continuous or remittent, but intermittent fever is the rule in tuberculosis.

The following tabulation of the temperatures of 223 cases admitted to the Ray Brook Sanatorium consists of two hourly readings from 7 A.M. to 9 P.M. for a period of eight days subsequent to admission. To separate the febrile from the non-febrile cases it was necessary to establish some arbitrary rule in the following tabulation: all cases that presented a temperature of 99.2° F. or above on three separate days were classified with the febrile group:

Incipient, 107; febrile, 45 or 42 per cent.; non-febrile, 62 or 58 per cent.

Moderately advanced, 76; febrile, 44 or 58 per cent.; non-febrile, 32 or 42 per cent.

Advanced, 40; febrile, 32 or 80 per cent.; non-febrile, 8 or 20 per cent.

Average maximum temperature of 45 incipient cases, 99.8° F.

Average maximum temperature of 44 moderately advanced cases, 100° F.

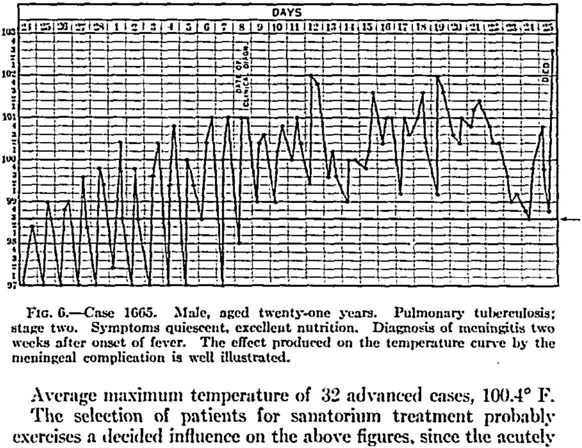


FIG. 6.—Case 1665. Male, aged twenty-one years. Pulmonary tuberculosis; stage two. Symptoms quiescent, excellent nutrition. Diagnosis of meningitis two weeks after onset of fever. The effect produced on the temperature curve by the meningeal complication is well illustrated.

Average maximum temperature of 32 advanced cases, 100.4° F.

The selection of patients for sanatorium treatment probably exercises a decided influence on the above figures, since the acutely ill are excluded. Nevertheless, these figures indicate that the percentage of febrile cases and the degree of temperature increase with the stage of the disease.

An endeavor has been made to establish a connection between fever and the stage of the disease, and, *a priori*, there would seem justification for this classification, since the degree of temperature should be closely related to the amount of lung infiltration. However a considerable number of cases cannot be so classified. The degree of saturation of the blood and tissues with toxin is in direct proportion to the absorptive powers of the contiguous tissues surrounding the focus. Their ability or inability to impede peripheral absorption is one of the factors which determine the degree of fever present. Concerning a second factor the protective substances generated by the tissues, nothing definite can be said, but clinical experience would lead us to believe that fever is also definitely influenced by these agents. Furthermore, individual susceptibility of the heat-regulating centre must be remembered. These factors, peripheral absorption, the presence of protective substances, and the condition of the heat regulating centres offer some explanation why certain cases with a slight initial lesion show grave constitutional symptoms, while others with gross pulmonary lesions may remain afebrile.

Miliary tuberculosis requires special consideration, in that a considerable degree of temperature is usually present at the onset and may be ushered in by chills, with rapid rise in temperature to 104° F. or above. The pyrexia may persist in the form of a continued fever, can assume an irregular remittent character, or, for short periods, be intermittent. The entire course of the disease may be characterized by moderate or even slight elevations of temperature. The typus inversus morning temperature with afternoon decline, according to Brunnechi, is characteristic of this type of tubercle invasion.

Factors which Influence the Temperature. Sudden relatively high temperatures of short duration are commonly the result of non-tuberculous complications, throat inflammations, gastro-intestinal disturbances, etc. Tuberculous meningitis often has a depressant influence on the temperature and may give rise to decided fluctuations. Profuse hemorrhages and continued diarrhea often cause a fall in temperature. The temperature invariably registers higher after an exacerbation of the local inflammatory process, pleurisy, aspiration, following hemorrhages, etc. The anatomical position of the lesion has apparently no direct bearing on the temperature. The favorable effects resulting from cardiac insufficiency has been pointed out by many observers, and is explained on the basis of pulmonary stasis.

Diagnosis. The determination of fever is of great clinical value, forming, as it does, the cardinal index of the constitutional symptoms in tuberculosis, and one of the earliest and most reliable indications of tuberculous implantation. Since slight fluctuations of temperature are of great diagnostic value the question arises, at what point on the thermometer does normal temperature end and fever begin? Owing to the variability in the normal temperature as above mentioned, only an approximate estimate can be made in a given case; roughly, the maximum normal temperature ranges between 98.6° F. and 99.4° F.

Experience would seem to indicate that a mere transitory rise of temperature can be ignored in diagnosis, as various obscure factors may play a part in its cause. Slight elevations of temperature, 99.2° F. to 99.4° F., however, if persistent or recurring frequently, become of diagnostic value.

The extreme variability of the temperature curve in pulmonary tuberculosis materially decreases its value in diagnosis. Cornet says, "A temperature of 99.8° F., which is intermittent but obstinate, and which increases upon the slightest exertion, indicates tuberculosis unless some other etiological factor can be discovered." This is a satisfactory rule, but must be applied with caution, since not infrequently the other etiological factors can be excluded only with difficulty. The forwarding of patients to sanatoria because of an unexplained temperature, which later proves itself to be non-tuberculous, is not infrequent.

There are a few diseases in which the temperature curve so closely simulates that of pulmonary tuberculosis that a differential diagnosis is of extreme importance. These diseases may be classified as pulmonary and extra-pulmonary. In the first group the disease most frequently leading to error is influenza. The bacteriological examination is often the only available means for differentiation. Other conditions of less frequency are lung abscess, syphilis, actinomycosis, bronchiectasis, occasionally mediastinal tumor, and malignant disease. In the extra-pulmonary group may be included Graves' disease, gastro-intestinal conditions, syphilis, certain cardiac conditions, Hodgkins' disease, cryptic suppurations, malaria, and typhoid. The differential diagnosis of Graves' disease is of special importance, and not infrequently cases are admitted to sanatoria with this mistake in diagnosis. Gastric dilatation, intestinal toxemia, and chronic appendicitis are confusing, in that functional changes of the digestive tract are frequent in pulmonary tuberculosis. The anemia, the loss of weight, the malaise, and even the fever of secondary syphilis, in the absence of rash, sore throat, etc., may strongly suggest the presence of tuberculosis. An irregular intermittent fever extending over a period of months in a certain group of cardiac cases has of late received attention, since the diagnosis of these cases has frequently been confused with that of tuberculosis. The fever that occasionally precedes the glandular enlargement of Hodgkins' disease, and which is so frequently accompanied by weakness, anemia, loss of weight, and anorexia extending over many weeks, has led to the erroneous diagnosis of concealed tuberculosis in more than one case. Local pus pockets, especially in the nasal sinuses, with latent local symptoms, are often confusing. In malarial districts the malarial type of fever in tuberculosis renders differential diagnosis difficult. The fever of miliary tuberculosis is similar in many respects to that of typhoid, and the differential diagnosis forms one of the most difficult problems in clinical medicine.

PROGNOSIS. In the prognosis of pulmonary tuberculosis, fever is a most reliable index of the ultimate course of the disease. Fever that resists treatment always speaks for an unfavorable outcome. The height and duration of the fever affect the prognosis correspondingly. The absence of fever does not, as is often accepted, necessarily imply improvement. Progression of the disease in the absence of fever can be clinically demonstrated.

CONCLUSIONS. 1. There is a necessity for testing the accuracy of certified thermometers.

2. Normal temperature may vary within considerable limits.

3. The selective action of tuberculo toxin in pulmonary cases may directly affect other systems than the respiratory, and thus lead to error in diagnosis.

4. The temperature curve in pulmonary tuberculosis is protean in character, and may simulate that of many other diseases.

5. Fever is the cardinal symptom of incipient tuberculosis: its nature and persistence are of diagnostic import.

6. The persistence of fever bears a definite relation to prognosis.

The appended temperature charts are presented to illustrate types of fever in tuberculosis.

EXUDATES IN ARTIFICIAL PNEUMOTHORAX.

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WHEN one has had the experience of seeing a Lazarus rise from the dead, the incident will never be forgotten, and the procedure which enables this to be done will not be abandoned even though such dramatic successes are but few in comparison with the whole number of cases in which artificial pneumothorax is performed. This method is still in the experimental stage, and many more years' experience will be required to more truly indicate its limitations as well as the type of case in which it is likely to prove most successful. The mechanical conditions met with in advanced tuberculosis, as, for instance, adhesions, consistency of the lung to be compressed, thickness of cavity walls, metabolic reactions to compression, the state of the other lung, the effect upon complications, particularly those of tuberculous character, the alteration of circulation, position of the heart, and the effect of pressure upon